Jeffrey M Robbins. Material Similarity Expectations of Digitally Rendered Place Representations. A Master's Paper for the M.S. in IS degree. May, 2021. 65 pages. Advisor: Ryan Shaw

The literary theory of aesthetic illusion applied to an augmented reality user experience proposes that presence is enhanced when digitally rendered content corresponds to the physical context of information delivery. This material consistency benefit presents a challenge for vernacular architecture whose modern environment may have little resemblance to the visual historical record of place. This empirical study applies a mixed method analysis to understand Durham, NC resident assessments of place via an online survey distributed on Reddit.

Forty-four residents responded to the survey, each assessing five image pairs. Logistic regression models resulted in conflicting findings depending on which image similarity metric was utilized (Chi-Square Color Histogram or SIFT). Qualitative result code frequency confirmed the material similarity of architectural structure as the primary strategy respondents utilized. Respondent comments provide support that image features and scenes have varying information authority. Information competition between site redevelopment and archival content present an interesting future extension.

Headings:

Digital images

Cultural property

Human-computer interaction

Augmented reality

Built environment

Space

MATERIAL SIMILARITY EXPECTATIONS OF DIGITALLY RENDERED PLACE REPRESENTATIONS

by
Jeffrey M Robbins

A Master's paper submitted to the faculty
of the School of Information and Library Science
of the University of North Carolina at Chapel Hill
in partial fulfillment of the requirements
for the degree of Master of Science in
Information Science.

Chapel Hill, North Carolina

May 2021

Approved by

_____

Ryan Shaw

Table of Contents

Introduction

Augmented reality technology is credited with generating an immersive experience for its users. Immersive due to the phenomenological interactions afforded by the digital sensory experience. A component of that experience is the rich imagery that can be layered into the user's visual field. Unlike the perceptions of the physical environment, digitally layered images are only broadly materially constrained. Pokémon Go demonstrated to millions of users the acceptance of adding content with no material consistency to the physical present.

This material freedom may not extend to all domains of the augmented reality application. Within the concepts of collective memory and Massey's space dynamism, augmented reality offers society a medium to explore the pluralistic definitions of place meaning through representational expression. The most prominent visual enactment to date is to layer archival imagery in the user's geo-specific field of view. Gestalt principles of continuity and similarity would suggest that cultural augmented reality imagery would receive greater cognitive acceptance in the presence of shared materiality with the physical present. Existing research has applied Gestalt to augmented reality design and separately to architectural theory; however, the lens of Gestalt has not yet been used to assess cultural heritage augmented reality experiences.

Literature Review

Immersion

Immersive, as a descriptor, has evolved to be the primary differentiating aspect of augmented reality (AR). Cultural heritage informatics manifests in the utilization of archival material presented to users through digital means. If augmented reality applications utilize this same archival material challenges of awareness, interest, access, and collective representation are not solved by varying communicative medium. What then does AR have to offer in cultural heritage experience? The prevailing justification of AR relies on the terminology of immersion. However, a single definition of immersion does not exist nor one that esteems technological and built environment contribution equally.

Many definitions and refinements specify the meaning of immersion. Cipresso, Giglioli, Raya, and Riva (2018) describe immersion in the physical sense of digital transparency, a condition where the user no longer notices technological mediation. This definition, reliant on technological affordance, is enacted in the analysis of user experience in virtual reality (VR) supported by head-mounted displays (Shu, Huang, Chang, & Chen, 2019), sound quality (Narbutt, O'Leary, Allen, Skoglund, & Hines, 2017), and haptic interfaces (Wang et al., 2019). In reaction to this materialist framing, Witmer and Singer (1998) propose VR immersion as the perceived presence or the affective feeling of existing within the digital construct.

Construed within a VR environment, both of these definitions fail to embrace the situated delivery of content relied upon by augmented reality. Mount, Chambers, Weaver, and Priestnall (2009) acknowledge that an immersive environment ideally prevents the external world from disrupting the digital world's experience. Including spatial insulation as a contributor to immersion does not translate into AR applications where the present physical context is as important as the digital content delivered. Georgiou and Kyza (2017) recognize this gap and adjust the definition for immersion in AR to include the blending of the physical and digital worlds as constitutive.

Presence & Believability

Presence has typified the analysis of individual interaction with content preceding the emergence of immersion framed scholarship. As a recent marker, immersion derives its influencing authority from technological materiality (Coelho, Tichon, Hine, Wallis, Riva, 2006). A conceptual turn towards presence foregrounds environmental materiality for inclusion in critical inquiries. Descriptions of presence by Coelho et al. (2006) and Macintyre, Gandy, Bolter (2004) function as referential for immersion definition both in the presentations of non-mediation and the psychological state of "being there". Rather than defining immersion in the negative of excluding user recognition of mediation, presence appears by drawing the user into the scene.

Shubert, Friedmann, Regenbrecht (2001) found three factors that influence presence: spatial cognition, user attention, and realness. This study will not inquire into spatial cognition nor user attention, but due to the prevalence of "authenticity" tropes in cultural heritage, it will pursue an inquiry driven by realness. Augmented reality

applications are complex presentations of information. They generate engagement based on location or marker recognition, present multi-modal information including data-heavy three-dimensional models, and render data in a contextualized orientation that is responsive to users' unpredictable but natural movements through space. The complexity of information and presentation necessitates both high fidelity augments and highly performant hardware delivery tools. AR scholars have explored user assessment of presence determined by visual consistency of digital and material objects. Regenbrecht, Meng, Reepen, Beck, and Langlotz (2017) empirically studied the tuning of voxels by adjusting: size, number, shade, and light. Participants in the study viewed a live video feed with digital augments presented in a head-mounted display. Delivering all visual content via video feed enabled the study to modify voxels generating an artificial visual quality consistency between the physical and digital. Regenbrecht et al. (2017) concluded that consistent visual presentation of low fidelity visuals did not reduce user assessments of presence. Steptoe, Julier, and Steed (2014) utilized two treatments of non-photorealistic rendering to assess the impact on participants' evaluation of digital and physical object presentation. Using an ANOVA test comparing the two treatments and control, Steptoe et al. (2014) found a statistically significant difference in participants' assessments of the "realness" of the physical room, the present physical objects, and the digital objects. Compared to an unfiltered rendering, the study found that stylizing the digital and tangible with the same visual properties resulted in users feeling the containing room was more digital and the objects contained within more real. The inclusion of both of these studies is not to support the reduction of visual quality in cultural heritage augmented reality applications, as both of these should progress

commensurate with technological trajectory. Selectively, it is to foreground user assessments of consistent visual quality between the digital and physical representations of place mediated through AR. Visual quality consistency represents a challenge for cultural heritage AR since the visual quality of the archival material is likely to generate a discrepancy with modern image capture.

Augmented reality applications blend into the user's current frame either subtly (e.g., IKEA's digital asset chair in a user's living room) or overtly (e.g., a Pikachu from Pokémon Go standing outside of The Metropolitan Museum of Art) digitally rendered content. Reaching a state of presence and immersion is then preconditioned on a user's willingness to suspend disbelief and engage in the presented imaginary (Wolf 2014). Wolf's discussion of aesthetic illusion is applied to the narratology of fiction and proposes the concept of accessibility as a contributing factor for achieving and maintaining presence. It is the differing semantics of Wolf's accessibility from its enaction in HCI that is provocative. According to Wolf, accessibility relates to the consistency between representation and user's real-life concept acknowledging that real-life concept is subjective and complicated by sociocultural environs. Likewise, Turner, Hetherington, and Kosek (2015) expand presence theorization with the addition of "make-believe," suggesting that media users suspend disbelief when they "mirror" real-world embodiment. Neither of these two works directly comments on augmented reality or the stability between digital augment and modern representation. However, by extension, they are instructive. Place is not of a temporally static form. Cultural heritage AR applications that utilize archival imagery will engage in instances where the digital

augment shares consistency with the extant and others where this consistency materially no longer is present.

If user acceptance of place realness matters for presence, then in an AR cultural heritage application, it is beneficial to connect the digital archival image to the physical present. Creating the connection between imagery allows for the environment to be read as a singular entity both in visual perception as well as in formation and editing of individual meaning ascriptions. Gestalt psychology provides a lens with which to understand human visual perception and similarity assessments.

Gestalt Perception and Similarity

Gestalt psychology as a paradigm started in the early twentieth century in Berlin, Germany contributing to visual perception knowledge. Gestalt laws have been applied across disciplines inspiring research in Vision, Neuroscience, Cognitive Studies, Machine Learning, and Human-Computer Interaction. Gestalt psychology establishes perceptual meaning through the organization and structuring of the visually observed (Arnheim, 1971) (Wenger, 1997). Visual perception is pre attentively read in small units of lines, dots, and pixels (Fellenz, Hartmann, 1996). The brain then assembles these units into larger and larger Gestalt Wholes, which are groupings of units united as objects and aggregations of objects that manifest scenes (Wagemans et al., 2012). Unit measures of color, similarity, proximity, closure, and continuity influence the likelihood of whether units generate wholes (Coren, Girgus, 1980).

Paay and Kjeldskov (2008) apply these Gestalt principles to a user study of a tourism location-based services mobile application. Participants interact with contemporary landscape views of Federation Square in Melbourne and contextualized

text information. User interviews thematically concluded that interactions with information occurred across digitally-mediated representations of place and physical place. User comments connecting information between the digital and physical confirmed that users visually perceived the mediated combined context as a Gestalt Whole. Meaning, as created by structure and influenced by similarity, was also discovered as a theme as users highlighted during interviews correspondences and relations between mediated photos of place and the present embodied experience.

Spatial form is not static; therefore, augmented reality renderings of archival photography likely will find image presentations where there are varying degrees of similarity with the material present. The Interaction Design Foundation (2020) discusses web URL presentations on websites as exemplars of Gestalt similarity. Despite web URL text and referential variance, the consistent presence of the Gestalts of color and similarity (underlined, hover cursor change) allows the user to associate meaningful relationships of affordance across URL links. Similarly, although not exact visual replicas, users may be able to generate connections between the archival and contemporary place in a way that acknowledges the multiplicity of place meaning.

Research Questions

This study assessed how layered digital image annotations affect Durham, NC resident assessments of place continuity by answering the following sub-questions.

1. Does material similarity correlate with participants' assessments of place sameness?
2. Does material similarity correlate with participants' confidence in place sameness assessments?
3. How influential is material similarity in participants' assessments of place sameness?
4. Does image presentation (side by side vs. layered) correlate to participants' assessments of image boundaries?
5. Do participants' descriptions of the process involved in place similarity assessments confirm place similarity as impactful?

Methods

Guided by a postpositivist epistemology (Schulze, 2003), the research design selected was a mixed-methods online survey. McKim (2017) suggests that the benefits of a mixed-method design include the ability to gain "a deeper, broader understanding of the phenomenon than studies that do not utilize both a quantitative and qualitative approach" (p. 2). The survey included both quantitative and qualitative data collection, with neither given preferential weighting during interpretation. Rather than seeking to improve perceptions of research validity through triangulation of results, participants' qualitative content improved validity by adding interpretative content to participant responses regarding one of the variables of interest, participant place definition. The opportunity to provide additional context addressed the concern raised by Toomela (2008) that quantitative variables reduce interpretation clarity by encoding multiple underlying causalities. Data was collected using a web survey instrument. In quantitative survey design, generalizability as a targeted outcome is controlled by managing sampling bias and sample size. While important, these two considerations are not foundational to mixed methods design, which emphasizes transferability over generalizability (White, 2006).

The thirty-six question survey (Appendix 1) contained both quantitative and qualitative questions. The first two questions baselined users' place definition while providing an assessment point to flag low-quality respondent data. The image pair order presentation was randomized in each survey to control for learning effects. The core

content, located in the middle of the survey flow, included participant similarity assessments of five image pairs (Figure 1).

Figure 1. Image pairs presented to survey respondents for similarity comparison. Images in the right column and left column for Moto obtained from www.opendurham.com

Each survey block displayed an archival photo to the participant in conjunction with a contemporary representation of place. After being asked to state whether the images represented the same place concretely, participants recorded their confidence in making the similarity assessment. In the conclusion, the survey asked participants to provide textual descriptions of the motivating factors leading to each similarity assessment. The five sets of image pairs varied the amount and type of similarity between the two place representations, including variations in the built environment, landscape, and geo-location similarity.

One method utilized by content-based image retrieval (CIBR) for calculating image similarity scores is a distance measure of pixel intensity histograms (Kumar, Esther, 2011). The approach converts an image into a histogram for each color channel (R, G, B) and then calculates the distance of the query image histogram against items in the image database. Prior to calculating Chi-Squared Color Histogram similarity, images were converted to greyscale and divided into 32 regions. Outside of the baseline comparison, all five of the presented image pairs coupled a historical photo with a present-day photo taken by the researcher using an iPhone. The difference in age and image capture device created color variations between the two photos, which would skew an RGB channel distance measure. An extreme example is the image pair Moto which compared a black and white, pixelated historical photo with a newer color web photo. To compensate for the noise these variations would contribute to an image similarity metric image processing included conversion to greyscale.

The color histogram distance method is classified as a global feature detection because it considers only pixel occurrence frequency and not occurrence and location (Li, Wang, Widerhold, 2000). This study implemented region-based image retrieval techniques described in Moghaddam, Biermann, Margaritis (1999), first dividing each image into 32 equally sized sectors. The availability of these 32 sectors resulted in Chi-Square Color Histogram distances reflective of a localized area in the image. Rather than a single color histogram distance measurement between the images, Table 1 reports the average Chi-Square distance between corresponding image regions.

Table 1

Chi-Square Color Histogram Distance Image Similarity

Image Set Name	Average Similarity Score
HouseReloc	0.5612191
Gray	0.5997057
Rail	0.6285933
Liberty	0.6403603
Moto	0.6486616

Figure 2. Greyscale pixel intensity differences for Rail image set. Historical image, prior to greyscale conversion, obtained from www.opendurham.com

An alternative image similarity metric to color histogram distance is keypoint detection and matching. Lacheheb and Aouat (2017) proposed optimizing image retrieval through the combination of querying global feature color histograms and local feature points. Local feature points were derived using scale-invariant feature transformation (SIFT) from the OpenCV Python library. SIFT is not sensitive to image rotation, lighting, perspective, or scale (Bakar, Hitam, Yussof, 2013). The identification of keypoints and vector descriptions in each study image allowed for a comparison between images searching for common feature points. SIFT keypoint matching between images does not

precisely pair one start point to only one identified endpoint; instead, the algorithm suggests multiple potential endpoints (Figure 3). The SIFT image similarity score for this study limited the number of keypoint matches to those with a nearest neighbor distance ratio less than 0.85, the next closest suggested match. LV, Teng, Lu (2016) applied this filtering, with a differing threshold, to limit the noise of SIFT proposed matches. Table 2 details the number of keypoint matches per image pair, representing the SIFT image similarity score.

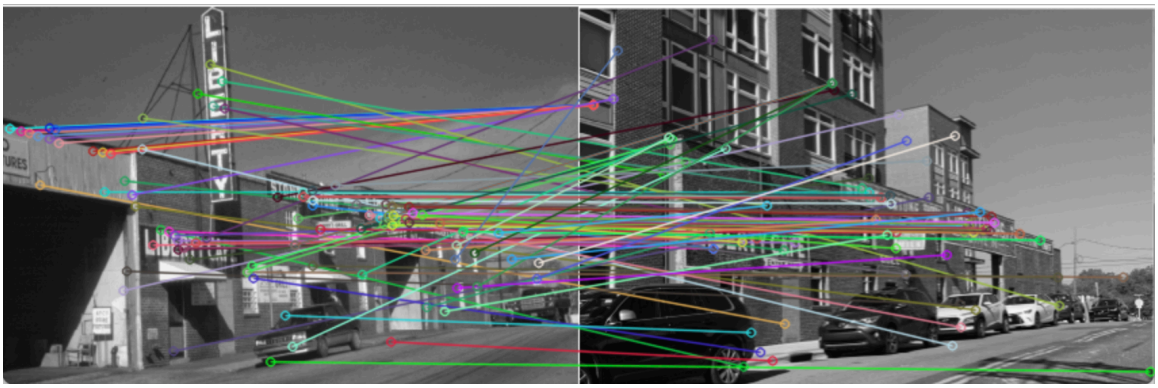

Figure 3. SIFT keypoint matches post nearest neighbor ratio for Liberty image pair. Historical image (left), prior to black and white transformation, obtained from www.opendurham.com

Table 2

Local Feature Keypoint Image Similarity

Image Set Name	Keypoint Count
Gray	15
Rail	20
HouseReloc	23
Moto	24
Liberty	90

A forum post to the subreddit “r/bullcity”, 19,300 members, requested users complete the survey instrument and provided the web URL for the Qualtrics survey. Amaya, Bach, Keusch, Kreuter (2019) state that Reddit users are not representative of the general population being both younger and more male. Shatz (2017) is not as definitive on the gender bias citing studies that have concluded both balanced gender and male majority conclusions. Reddit post visibility is ephemeral; prior research studies have found that participant responses reach saturation within the first three days of posting with a recommendation to post at 9 AM eastern on a Monday to optimize views (Shatz, 2017). Reddit posts are subject to voting up and down, which, combined with posting date, affects ordering within the forum. Post visibility and potential response rate can then be influenced by Reddit members exercising agency (Amaya, Bach, Keusch, Kreueter, 2019). The same study also reported that the majority of Reddit user interactions are from a mobile browser. Fortunately, Qualtrics enables the adaptive display to accommodate various screen sizes.

Results

The survey collection link was left open for data collection for one week, with 95% of responses recorded in the first 48 hours following the Reddit post. Seventy-three responses were recorded, representing a 0.38% collection percentage from the population of r/bullcity members at the time of posting. Data cleaning efforts removed respondent abandonments and those responses where the respondent indicated they were not a resident of Durham, NC. The resultant usable data set was 44 responses, a 60% retention rate. Compared to Shatz (2017), this study's Reddit data collection achieved a higher response rate but a lower post-start retention rate.

Respondent demographics for this study did not support prior research statements that Reddit data collection generates young male data samples. Of the 44 usable responses, 19 respondents identified as female and 25 identified as male. Respondent reported age distribution is heavily concentrated in the 23 – 50 years old range (Figure 4).

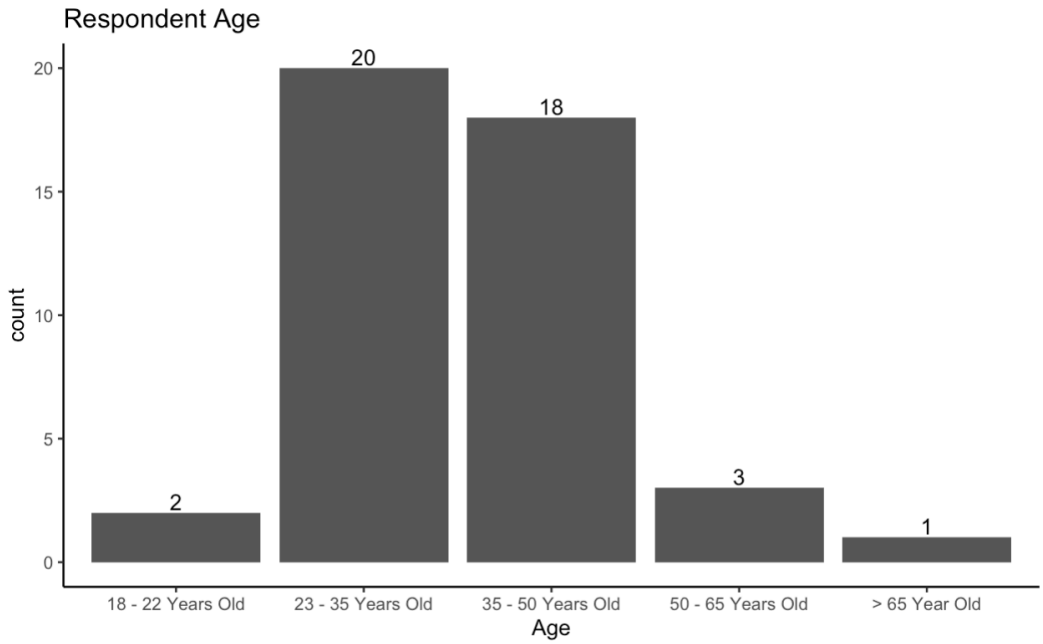

Figure 4. Respondent identified age histogram.

To remove any effect of non-residency, cleaned responses included only respondents who indicated residency in Durham, NC. The majority of respondents in this sample resided in Durham, NC, for greater than ten years (Figure 5). Given respondent tenure in Durham, it is not surprising that many respondents had personal experience with the sites represented by the survey images (Table 3).

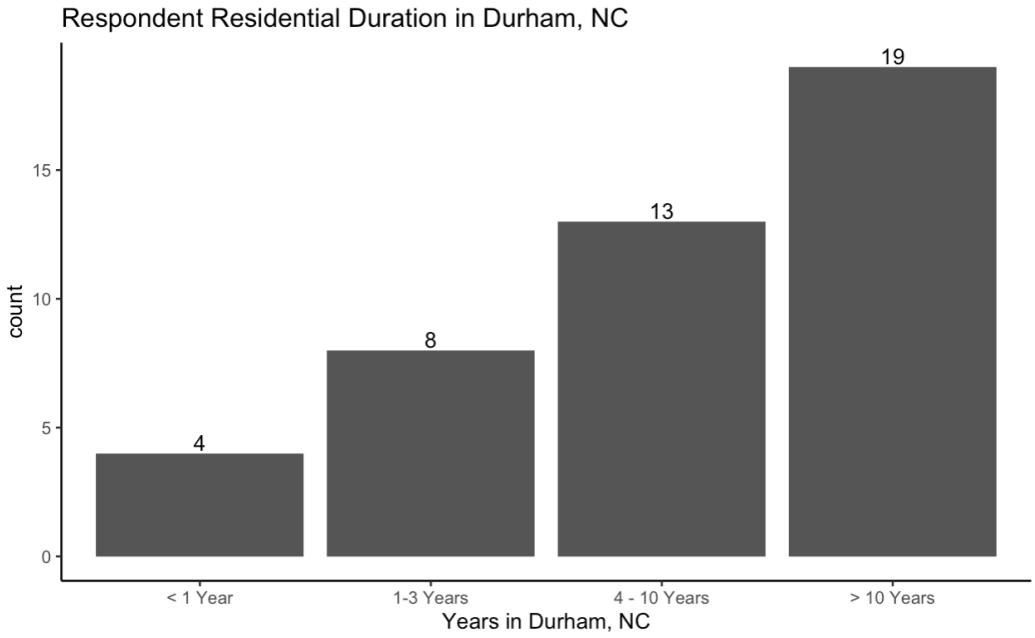

Figure 5. Respondent residential history in Durham, NC histogram.

Table 3

Percent of Respondents Who Have Previously Interacted with Survey Sites

Image Set Name	Prior Experience (%)	Prior Knowledge (%)
Gray	64	23
HouseReloc	5	0
Liberty	77	36
Moto	34	7
Rail	77	16
		n = 44

Survey respondents judged each presented image set in the survey and indicated whether the image representations were the same "place". Respondents were then asked to select how confident they were in making the sameness judgment for each image pair. All but two image sets received a majority opinion that both representations were the

same, except for HouseReloc and Rail (Figure 6). These two image sets also had the largest frequency dispersion of respondent confidence scores (Figure 7).

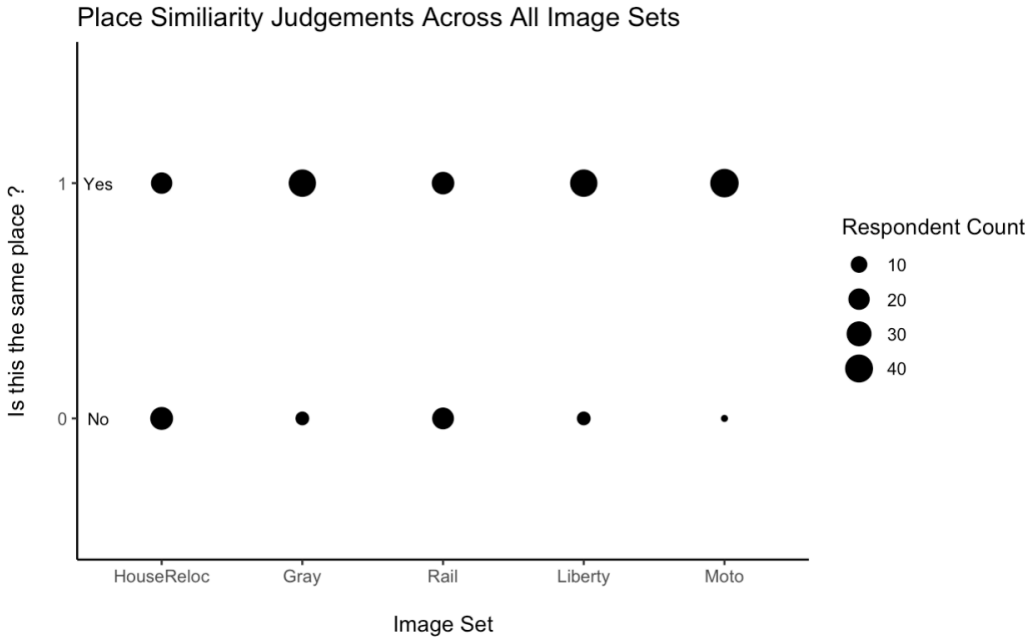

Figure 6. Respondent place similarity assessments across all image sets.

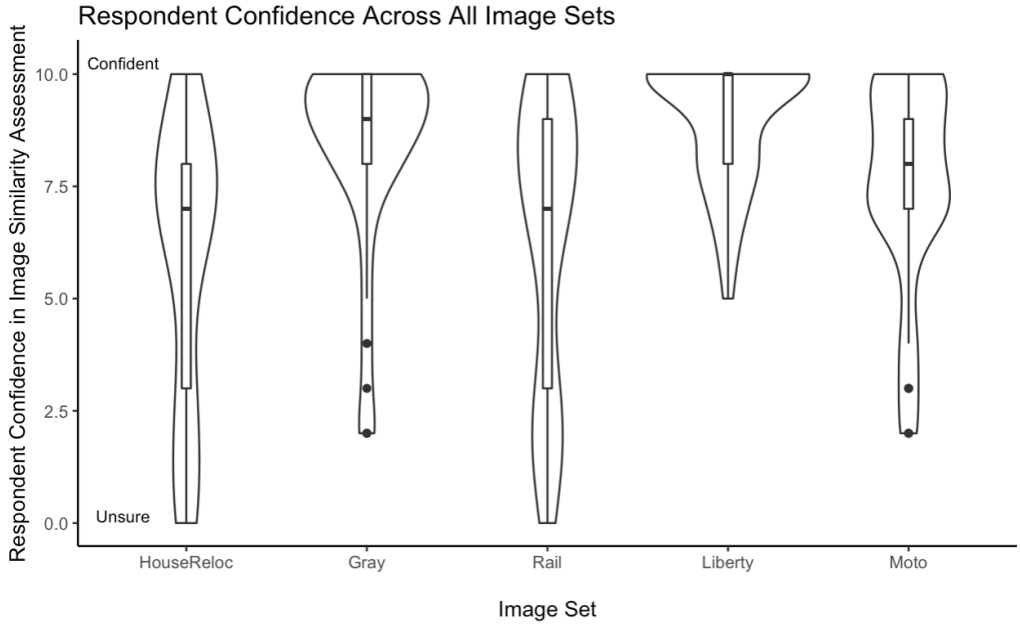

Figure 7. Respondent place similarity assessments across all image sets.

An ontological understanding of "place" was consequential for respondents when interacting with the survey instrument. Qualitative comments received included restatements of personal place definition, assumptions that the research study purpose was to understand the definition of place, and challenges to the assumed researcher definition of place. The concept of "place" was so central to some participants that they publicly posted on the survey advertisement post asking the researcher how to define place. Respondents were provided the opportunity at the end of the survey to self-identify their definition of place on a spectrum of 0 (materialist) – 10 (constructivist). The majority of respondents rated themselves between 1 – 5 (Figure 8), setting the expectation that this sample values material similarity.

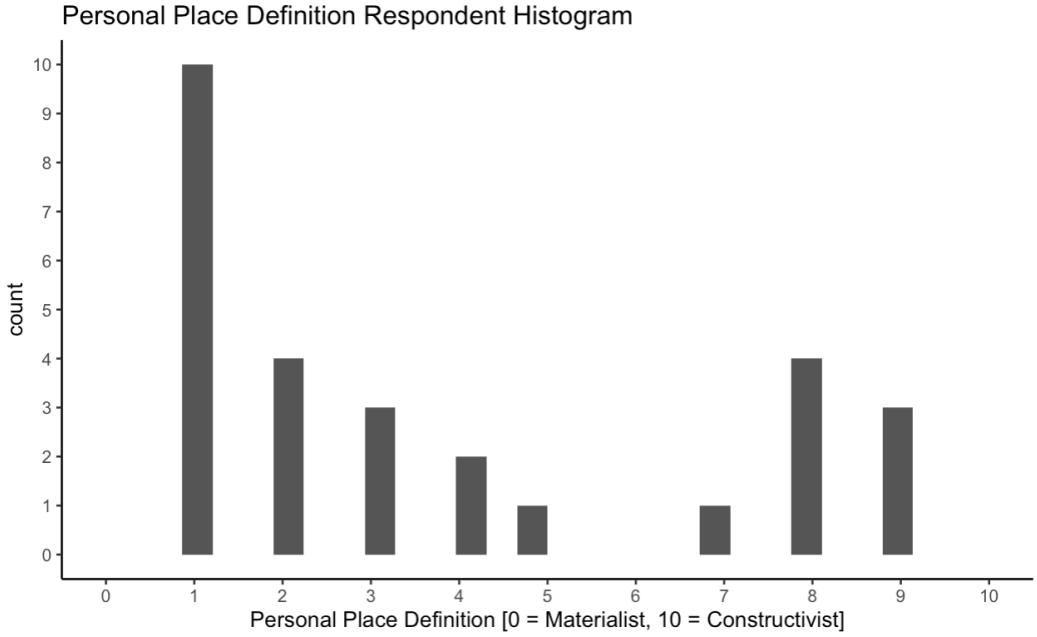

Figure 8. Respondent personal place definition histogram.

Research Question One

Correlation statistics between respondent place sameness assessments and the two image similarity measures (Table 4) generated opposing results. Khamis (2008) guides the use of the point biserial correlation for correlations between a continuous variable (Chi-Square Similarity Score/SIFT) and a dichotomous variable (respondent place sameness assessments). A Welch T-Test found the ChiSquare Color Histogram variance was not the same between the dichotomous categories. Bonnet (2020) recommends point biserial correlation for samples with unequal variance between classes.

Table 4

Respondent Place Sameness Assessments by Image set and Image Similarity Score

	Similarity Score		Respondent Counts	
Image Set Name	Chi-Square Color Histogram	SIFT	Not the Same Place	Same Place
Gray	0.5997057	15	6	38
HouseReloc	0.5612191	23	24	20
Liberty	0.6403603	90	6	38
Moto	0.6486616	24	2	42
Rail	0.6285933	20	21	23

A 0.295789 correlation coefficient with a p-value of 8.099819e-06 between the Chi-Square Color Histogram measure and respondent place sameness assessments indicates a weak statistically significant, at 5% level, relationship between an increase in the dissimilarity of the color histograms and respondent selection that the two images are the same place. A correlation coefficient of 0.1392215 with a p-value of 0.03908571 between the SIFT similarity measure and respondent place sameness assessments indicates a weak, statistically significant, at 5% level, relationship between an increase in

the number of matching features between images and respondent selection that the two images are the same place.

Research Question Two

Similar to research question one, the Kendall rank correlations offer opposing conclusions dependent on image similarity metric selection (Figure 9 and Figure 10).

Figure 9. Correlation visualization between Chi Square Color Histogram image similarity and respondent confidence in making place sameness assessment.

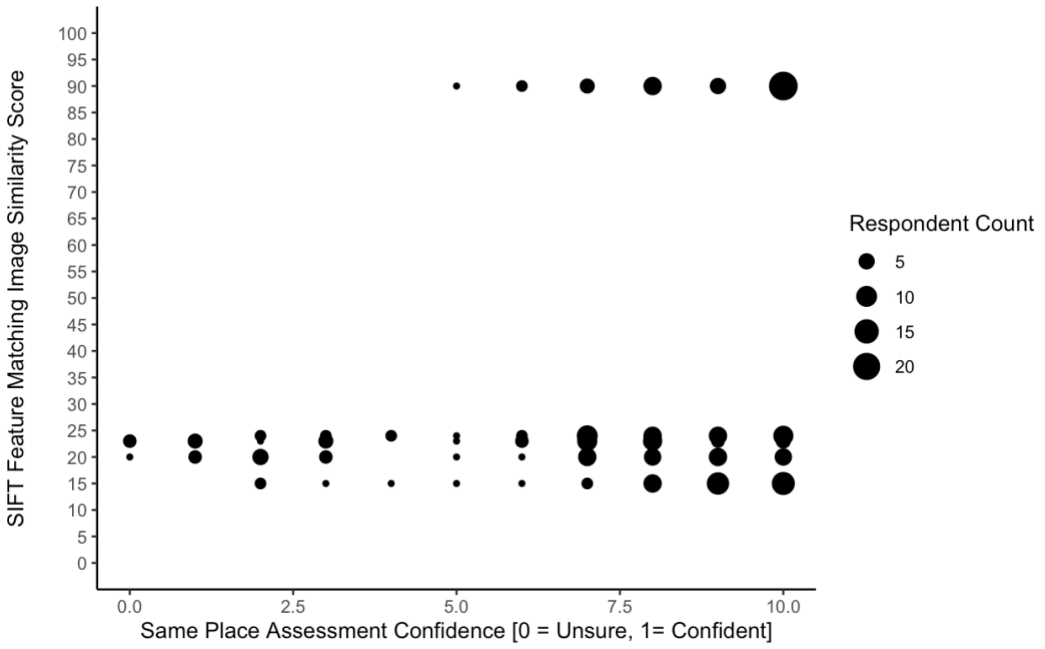

Figure 10. Correlation visualization between SIFT image similarity and respondent confidence in making place sameness assessment.

A 0.136 tau with a p-value of 0.013479 between the Chi-Square Color Histogram measure and respondent confidence indicates a statistically significant, at 5% level, weak relationship between an increase in the dissimilarity of the color histograms and respondent confidence in the place sameness selection made. A tau of 0.101 with a p-value of 0.067058 between the SIFT similarity measure and respondent confidence in the place sameness selection made indicates a non-statistically significant, at 5% level, weak relationship between an increase in the number of matching features between images and respondent confidence in the place sameness selection made.

Research Question Three

A logistic regression predicted respondent place sameness assessments using the independent variables: Chi-Square Color Histogram Image Similarity, Prior Experience with Place (Yes/No), Prior Knowledge of Place (Yes/No), Personal Place Definition (0

Materialist – 10 Constructivist), and Trust of Digital Information (0 Skeptical – 10 Trusting). The results found a statistically significant, at the 5% level, effect for both Chi-Square Color Histogram Image Similarity and Personal Place Definition. The coefficient estimates for a logistic regression constitute an increase or decrease in the probability of the dichotomous dependent variable represented by a value of 1. In this study, a value of 1 for respondent place sameness assessment reflects a respondent judging the place as the same. The Chi-Square Color Histogram Image Similarity score has a range in this study of 0.561 – 0.648. Table 5 would then suggest that a 0.01 increase in the Chi-Square similarity metric (images are becoming more dissimilar) results in a 24% increase in the probability the images receive an affirmative place sameness response.

Table 5

Logistic Regression Using Chi-Square Color Histogram Image Similarity

Coefficient	Estimate	Std. Error	Z Value	Pr(>|z|)	
(Intercept)	-11.00302	3.95102	-2.785	0.00536	**
SimilarityChiSquare	21.89702	6.69400	3.271	0.00107	**
PriorExperience	-0.58775	0.47235	-1.244	0.21338	
PriorKnowledge	-0.47703	0.54550	-0.874	0.38186	
PersonalPlaceDef	-0.11071	0.05238	-2.113	0.03456	*
DigitalInfoTrust	-0.07669	0.07500	-1.023	0.30654	

Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

The second logistic regression model replicated regressors but included the alternate image similarity metric, SIFT. This regression (Table 6) shows that image similarity is no longer significant, but personal place definition remains significant at the 5% level. The recurrence of personal place definition is intuitive to understand. Respondents who personally define place as social interactions are less likely to assess

two images of place as the same if evidence exists that the images were captured at different moments in time.

Table 6

Logistic Regression Using ChiSquare Color Histogram Image Similarity

Coefficient	Estimate	Std. Error	Z Value	Pr(>|z|)	
(Intercept)	1.700628	0.601559	2.827	0.0047	**
SimilaritySIFT	0.012830	0.007625	1.683	0.0924	
PriorExperience	-0.104922	0.408394	-0.257	0.7972	
PriorKnowledge	-0.546449	0.550364	-0.993	0.3208	
PersonalPlaceDef	-0.110383	0.050862	-2.170	0.0300	*
DigitalInfoTrust	-0.072720	0.072922	-0.997	0.3187	

Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Research Question Four

Survey respondents assessed two image pairs for 'Moto' that were identical except for the images' visual arrangement (Figure 11). In the first exposure, side-by-side orientation presented the images, consistent with all other image pairs in the study. In the second presentation, layered images acted as a simplified proxy for an augmented reality experience with the two places.

Figure 11. Moto's differing presentation treatment to survey respondents. Images obtained from www.opendurham.com

No difference existed in survey data between respondent answers to the number of places represented in each image or whether the image was the same between the two

presentation treatments. Of the 44 cases in the dataset, only one differed in the place sameness assessment and only three in the number of places identified in the images. The lack of qualitative data collection for the AR layered presentation treatment prevents further differentiating analysis.

Research Question Five

As part of the survey's concluding tasks, participants were re-presented with each of the five image sets and asked to describe the supporting evidence for their sameness conclusion. The thematic analysis completed did not utilize pre-defined codes but was sensitive to locating data indicative of the respondent's personal place definition (i.e., either materialist or constructivist). As the coding progressed, lower-level codes were defined and applied. Appendix 2 includes the codebook and occurrence counts for the thematic analysis completed.

The most frequently occurring theme (n=119) was respondent comments related to structural comparisons between the two images. Code co-occurrence (Figure 12) reveals consistency between the visual materialist strategies employed and the image similarity score ordering of the image pairs by the SIFT method (Table 2). For image sets, HouseReloc, Rail, and Gray structure and location themes occurred with similar frequency. This contrasted respondent comment behavior for the Moto and Liberty image sets, which had higher numbers of SIFT keypoint matches, and respondent comments concentrated on structural assessments.

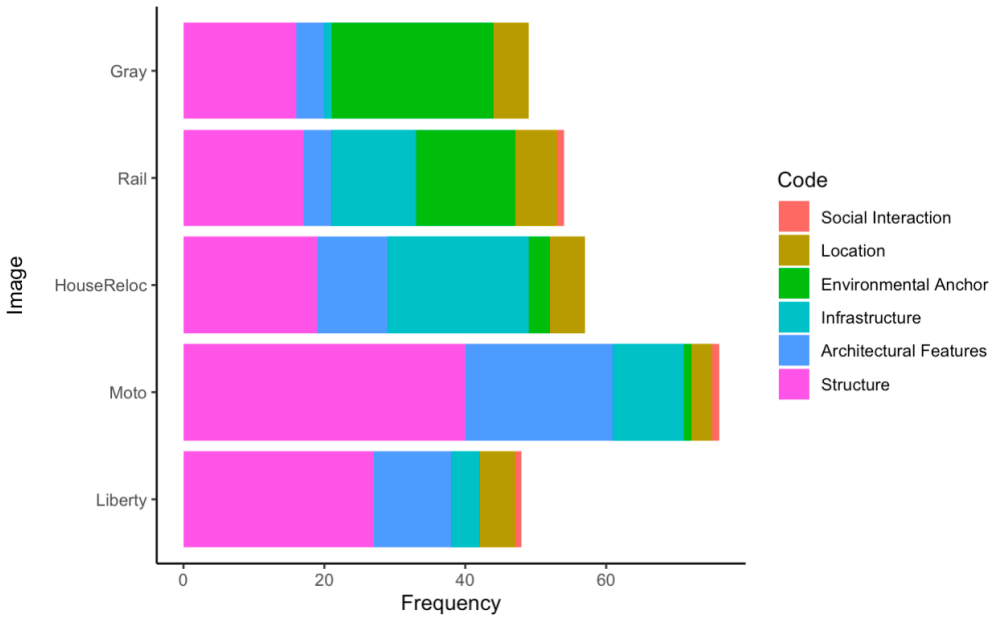

Figure 12. Code cooccurrence frequency by image.

Discussion

The preponderance of respondents who personally identify with materialist evaluations of place (Figure 8) combined with the statistically significant result of personal place definition's impact on place sameness assessments (Table 5, Table 6) supports the overwhelming presence of comparative structural comments in the qualitative data (Table 8). A detailed inspection of these comments reveals a nuanced understanding of material similarity expectations for this specific sample in the areas of strategic intent, feature focus and place uniqueness, and visual processing competition.

The study did not define material similarity for respondents. Instead, individuals adaptively defined this term personally for each image set; in some cases, defining it based on material construction comparisons while in others using environmental sameness to support the equalization of depicted geographical location. Particularly in the image sets Gray and Rail, where the central subject matter building in the historical image was absent from the modern image, environmental anchors appear in respondent comments. One respondent stated concerning Gray,

> "It is difficult to tell whether the pictures are supposed to have been taken from the same precise spot, and the building in the foreground of the older picture is not present in the other picture. But the large building in the background appears to be the same in both pictures, and has enough unique distinguishing characteristics (windows, floors, etc.) that I believe it is the same."

In Places of Public Memory, Gallagher and LaWare (2010) argue that physical context impacts place interpretation. This study finds that establishing two images regarding the same referent prior to interpretative analysis is based on shared environmental information. This finding has practical implications for augmented reality development in expanding visual designer focus beyond primary subject matter to include the comprehensive image landscape.

When the subject matter building structure is present, as is the case for image sets Moto, Liberty, and HouseReloc, respondent comments on visual similarity focus on material structural features. The most salient features mentioned by respondents, when present, were text features as found in the image set Liberty (Figure 1). One respondent representing many similar comments stated, “Placement of Liberty Cafe signs is identical”. In image sets where text features were not visually present, respondents narrowed visual attention to the architectural features of rooflines, façade materials, and door and window layouts. The human interest in the information windows provide regarding image similarity in this study reinforces research completed by Haugeard, Philipp-Foliguet, and Precioso (2009), where building image retrieval utilized window feature extraction as building descriptors. The repeated use of a specific feature suggests that not all image features hold the same information authority when making similarity assessments. When writing about a similarity comparison of the Rail image set, one respondent commented, “Railroads tracks never move so they may be the same place”. For this respondent and others, railroad tracks as infrastructure signify object permanence and can be relied upon for location confirmation. Similarly, a respondent commenting about the Moto image set stated, “The weird angle of the side wall in the

building makes me pretty sure it's the same in both photos." Respondent comments focusing on weirdness and oddity of the visual perceived content reinforce that unique features registered in both images are appreciable indicators for place sameness.

A rationalist perspective would expect respondents to differ from their peers in the methodical practice of image assessment but be personally consistent across image assessments. The study sample does not support this perspective. Respondent comments demonstrate that visual information perception can be differentially processed based on visual category. Respondent statements related to HouseReloc (Figure 1) highlighted that respondents approach similarity assessment differently for industrial and residential architecture. One representative comment from the thirteen similar comments was,

> "Houses are not as unique as other larger buildings and are frequently made to the same plan, so two pictures of similar-appearing houses are less likely a priori to be the same place."

No similar comments related to industrial image sets existed where a respondent suggested doubt in whether the industrial structure was a repetitively produced object. In the presence of significant material similarity, respondents applied a more skeptical assessment practice for residential architecture.

Material similarity supports the development of aesthetic illusion, but information competition disrupts image sameness perception. Two of the image sets, Rail and Gray, contained multiple physical structures in each image, with one missing in the modern photo (Figure 1). The similarity of experimental treatment between these two image pairs did not result in a similar distribution of image sameness assessments. Figure 6 demonstrates the majority of respondents classified the Gray image as the same place while the Rail image set had a balanced distribution in place sameness assessments.

Fifteen recordings of “No” were submitted for the place sameness assessment of the Rail image pair, while these same respondents indicated “Yes” for the Gray image pair. All qualitative responses for Gray rationalized place sameness using environmental anchors of surrounding structures which is interesting because environmental anchor buildings were also present in the Rail image. The existence of these anchor buildings was not equally recognized nor employed as a sameness strategy across the two image sets because of information competition. The Gray image set’s visual subject, a historical building, was demolished with no replacement building constructed. The blank canvas of the modern photo required respondents to focus on the environmental anchors out of necessity due to a lack of visual information. Contrary to Gray, the Rail image set visualized the historical structure’s replacement through redevelopment, creating information competition between the modern representation and the historically imagined illusion of the former place. The lack of material similarity in the focal structure dominated respondent assessment attention distracting from utilizing the same environmental anchor strategy.

Limitations and Future Research

The number of individuals who responded to the survey was acceptable for a non-generalizable study and consistent with other Reddit recruitment experiments (Shatz, 2017). Each individual reviewed the same five image sets, which resulted in robust qualitative comment comparisons but reduced the quantitative data analysis's explanatory power. Though the regressors for personal place definition, knowledge of place, experience of place, and trust of digital materials had the potential for variability across each of the 44 individual respondents, the material similarity score (Chi-Square Color Histogram or SIFT) had a maximum variation of 5. Future studies looking to rationalize material similarity expectations in image comparisons quantitatively should increase the number of image pairs reviewed randomly by survey respondents.

The lens of information competition during image cognition is a compelling result of the study and potential research topic for future exploration. In rural contexts and historical land sites, redevelopment is not likely to occur. Though the material structure may no longer exist, a historic reconstruction via a digital experience may be able to leverage aesthetic illusion to connect old knowledge to new meaning for audiences. In the urban context, specifically vernacular architecture that has not received preservation protection, it is likely that redevelopment has occurred, creating information competition for any digital experience that competes in the visual presentation of a former state. Acknowledging an increased difficulty in presenting the historical urban imaginary contemporaneously with a modern structure and identifying human-computer interaction

mechanisms to lessen this difficulty represents a topic that cultural heritage informatics scholars should explore.

Conclusion

Perceived content believability improves the achievement of presence in the digital user experience, according to existing literature. In virtual worlds, the immersive goal is for the application user to lose awareness of the physical environment through engagement with the digital. The loss of external awareness is counter to the ideal experience of an augmented reality application where external context is additive to the digital content viewed. Augmented reality does not prioritize digital information over physical, contextual information. Instead, the application immerses and teaches through connection. This study took the first step inspecting the influencing factors fostering the relatedness between visual information in the vernacular built environment. A mixed methods approach analyzed survey respondent data from five image pairs comparing a historical photo and a modern photo of corresponding geographic location. Quantitative results support a relationship between image visual similarity scores (Chi-Square Color Histogram and SIFT) and respondent place sameness assessment, but of opposing directionality. Qualitative results demonstrate the dominant presence of built environment structural comparison statements made by respondents when justifying their place sameness selection. Though material similarity assessments were conducted in the majority of image pair reviews, respondents did not deploy the strategy uniformly. The study found feature comparisons varied based on feature type and scene context, both of which are areas of research opportunity in the continued exploration of augmented reality in the cultural heritage built environment.

Bibliography

Amaya, A., Bach, R., Keusch, F., & Kreuter, F. (2019). New Data Sources in Social Science Research: Things to Know Before Working With Reddit Data. Social Science Computer Review, 0894439319893305. https://doi.org/10.1177/0894439319893305

Arnheim, Rudolf. (1971). Entropy and art; an essay on disorder and order. University of California Press. https://catalog.hathitrust.org/Record/001379632

Bakar, S. A., Hitam, M. S., & Yussof, W. N. J. H. W. (2013). Content-Based Image Retrieval using SIFT for binary and greyscale images. *2013 IEEE International Conference on Signal and Image Processing Applications*, 83–88. https://doi.org/10.1109/ICSIPA.2013.6707982

Bonett, D. G. (2020). Point-biserial correlation: Interval estimation, hypothesis testing, meta-analysis, and sample size determination. *British Journal of Mathematical and Statistical Psychology*, *73*(S1), 113–144. https://doi.org/10.1111/bmsp.12189

Christian, L. M., Parsons, N. L., & Dillman, D. A. (2009). Designing Scalar Questions for Web Surveys. Sociological Methods & Research, 37(3), 393–425. https://doi.org/10.1177/0049124108330004

Cipresso, P., Giglioli, I. A. C., Raya, M. A., & Riva, G. (2018). The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster

Analysis of the Literature. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.02086

Coelho, D. C., Tichon, P. J. G., Hine, D. T. J., Wallis, D. G. M., & Riva, P. G. (2006). Media Presence and Inner Presence: The Sense of Presence in Virtual Reality Technologies. In G. Riva, M. T. Anguera, B. K. Wiederhold, & F. Mantovani (Eds.), *From Communication to Presence: Cognition, Emotions and Culture towards the Ultimate Communicative Experience* (pp. 25–45). IOS Press, Amsterdam. http://cogprints.org/5965/

Coren, S., & Girgus, J. S. (1980). Principles of perceptual organization and spatial distortion: The gestalt illusions. Journal of Experimental Psychology: Human Perception and Performance, 6(3), 404–412. https://doi.org/10.1037/0096-1523.6.3.404

Dickinson, G., Blair, C., Ott, B. L., & Lucaites, J. L. (2010). *Places of Public Memory: The Rhetoric of Museums and Memorials*. University of Alabama Press. http://ebookcentral.proquest.com/lib/unc/detail.action?docID=565716

Fellenz, W. A., & Hartmann, G. (1996). Preattentive grouping and attentive selection for early visual computation. Proceedings of 13th International Conference on Pattern Recognition, 4, 340–345 vol.4. https://doi.org/10.1109/ICPR.1996.547442

Georgiou, Y., & Kyza, E. A. (2017). The development and validation of the ARI questionnaire: An instrument for measuring immersion in location-based augmented reality settings. *International Journal of Human-Computer Studies*, 98, 24–37. https://doi.org/10.1016/j.ijhcs.2016.09.014

Haugeard, J., Philipp-Foliguet, S., & Precioso, F. (2009). Windows and facades retrieval using similarity on graph of contours. *2009 16th IEEE International Conference on Image Processing (ICIP)*, 269–272. https://doi.org/10.1109/ICIP.2009.5413408

Khamis, H. (2008). Measures of Association: How to Choose? *Journal of Diagnostic Medical Sonography*, *24*(3), 155–162. https://doi.org/10.1177/8756479308317006

Kumar, A., & Esther, J. (2011). Comparative Study on CBIR based by Color Histogram, Gabor and Wavelet Transform. *International Journal of Computer Applications*, *17*, 37–44. https://doi.org/10.5120/2199-2793

Lacheheb, H., & Aouat, S. (2017). SIMIR: New mean SIFT color multi-clustering image retrieval. *Multimedia Tools and Applications*, *76*(5), 6333–6354. https://doi.org/10.1007/s11042-015-3167-3

Li, J., Wang, J. Z., & Wiederhold, G. (2000). IRM: Integrated region matching for image retrieval. *Proceedings of the Eighth ACM International Conference on Multimedia - MULTIMEDIA '00*, 147–156. https://doi.org/10.1145/354384.354452

Lv, G., Teng, S. W., & Lu, G. (2016). Enhancing SIFT-based image registration performance by building and selecting highly discriminating descriptors. *Pattern Recognition Letters*, *84*, 156–162. https://doi.org/10.1016/j.patrec.2016.09.011

Macintyre, B., Bolter, J., & Gandy, M. (2004). Presence and the aura of meaningful places. *Presence Teleoperators & Virtual Environments*.

McKim, C. A. (2017). The Value of Mixed Methods Research: A Mixed Methods Study. Journal of Mixed Methods Research, 11(2), 202–222. https://doi.org/10.1177/1558689815607096

Moghaddam, B., Biermann, H., & Margaritis, D. (1999). Defining image content with multiple regions-of-interest. *Proceedings IEEE Workshop on Content-Based Access of Image and Video Libraries (CBAIVL'99)*, 89–93. https://doi.org/10.1109/IVL.1999.781130

Mount, N. J., Chambers, C., Weaver, D., & Priestnall, G. (2009). Learner immersion engagement in the 3D virtual world: Principles emerging from the DELVE project. *Innovation in Teaching and Learning in Information and Computer Sciences*, 8(3), 40–55. https://doi.org/10.11120/ital.2009.08030040

Narbutt, M., O'Leary, S., Allen, A., Skoglund, J., & Hines, A. (2017). Streaming VR for immersion: Quality aspects of compressed spatial audio. *2017 23rd International Conference on Virtual System Multimedia (VSMM)*, 1–6. https://doi.org/10.1109/VSMM.2017.8346301

Paay, Jeni, & Kjeldskov, Jesper. (2008). Understanding the user experience of location-based services: Five principles of perceptual organisation applied. Journal of Location Based Services, 2(4), 267–286. https://doi.org/10.1080/17489720802609328

Regenbrecht, H., Meng, K., Reepen, A., Beck, S., & Langlotz, T. (2017). Mixed Voxel Reality: Presence and Embodiment in Low Fidelity, Visually Coherent, Mixed Reality Environments. *2017 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, 90–99. https://doi.org/10.1109/ISMAR.2017.26

Shatz, I. (2017). Fast, Free, and Targeted: Reddit as a Source for Recruiting Participants Online. *Social Science Computer Review*, *35*(4), 537–549. https://doi.org/10.1177/0894439316650163

Shu, Y., Huang, Y.-Z., Chang, S.-H., & Chen, M.-Y. (2019). Do virtual reality head-mounted displays make a difference? A comparison of presence and self-efficacy between head-mounted displays and desktop computer-facilitated virtual environments. *Virtual Reality*, 23(4), 437–446. https://doi.org/10.1007/s10055-018-0376-x

Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The Experience of Presence: Factor Analytic Insights. *Presence: Teleoperators & Virtual Environments*, 10, 266–281. https://doi.org/10.1162/105474601300343603

Schulze, S. (2003). Views on the combination of quantitative and qualitative research approaches. Progressio, 25(2), 8–20.

Steptoe, W., Julier, S., & Steed, A. (2014). Presence and discernability in conventional and non-photorealistic immersive augmented reality. *2014 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, 213–218. https://doi.org/10.1109/ISMAR.2014.6948430

Toomela, A. (2008). Variables in Psychology: A Critique of Quantitative Psychology. Integrative Psychological and Behavioral Science, 42. https://link-springer-com.libproxy.lib.unc.edu/article/10.1007/s12124-008-9059-6

Turner, P., Hetherington, R., Turner, S., & Kosek, M. (2015). The Limits of Pretending. *Digital Creativity*. https://www.researchgate.net/publication/283266170_The_Limits_of_Pretending

Wang, D., Guo, Y., Liu, S., Zhang, Y., Xu, W., & Xiao, J. (2019). Haptic display for virtual reality: Progress and challenges. *Virtual Reality & Intelligent Hardware*, 1(2), 136–162. https://doi.org/10.3724/SP.J.2096-5796.2019.0008

Wagemans, J., Feldman, J., Gepshtein, S., Kimchi, R., Pomerantz, J. R., van der Helm, P. A., & van Leeuwen, C. (2012). A century of Gestalt psychology in visual perception: II Conceptual and theoretical foundations. Psychological Bulletin, 138(6), 1218–1252. https://doi.org/10.1037/a0029334

Wenger, R. (1997). Visual Art, Archaeology and Gestalt. *Leonardo*, *30*(1), 35–46.

What are Gestalt Principles? (n.d.). The Interaction Design Foundation. Retrieved October 13, 2020, from https://www.interaction-design.org/literature/topics/gestalt-principles

White, M., & Marsh, E. (2006). Project MUSE - Content Analysis: A Flexible Methodology. Library Trends, 55(1), 22–45.

Witmer, B. G., & Singer, M. J. (1998). Measuring Presence in Virtual Environments: A Presence Questionnaire. *Presence: Teleoperators and Virtual Environments*, 7(3), 225–240. https://doi.org/10.1162/105474698565686

Wolf, W. (2014). Illusion (Aesthetic). In P. Huhn (Ed.), *The living handbook of narratology*. http://www.lhn.uni-hamburg.de/article/illusion-aesthetic

Appendix A: Online Survey

Place Similarity Judgments

Survey Flow

- Standard: Welcome and Informed Consent (1 Question)
- BlockRandomizer: 2 -
  - Standard: Same Baseline (5 Questions)
  - Standard: Different Basline (5 Questions)
- BlockRandomizer: 5 -
  - Standard: Moto (5 Questions)
  - Standard: Liberty (5 Questions)
  - Standard: Rail (5 Questions)
  - Standard: Gray (5 Questions)
  - Standard: HouseReloc (5 Questions)
- Standard: Layered (5 Questions)
- Standard: Moto - qual (4 Questions)
- Standard: Liberty - qual (4 Questions)
- Standard: Rail - qual (4 Questions)
- Standard: Gray - qual (4 Questions)
- Standard: HouseReloc - qual (4 Questions)
- Standard: Final Questions (6 Questions)
- Standard: Citation and Close (2 Questions)

Start of Block: Welcome and Informed Consent

Q1 **University of North Carolina at Chapel HillResearch Information SheetIRB Study #: 20-3484Principal Investigator: Jeffrey Robbins** The purpose of this research study is to learn how residents of Durham, NC make place similarity judgements between an old digital photograph and a modern photograph of the same or different location. You are being asked to take part in a research study because you viewed content on the Subreddit r/bullcity. Being in a research study is completely voluntary. You can choose not to be in this research study. You can also say yes now and change your mind later. If you agree to take part in this research, you will be asked to view 8 pages of digital photos from Durham, NC, assess on each page whether images are the same or different places, provide your confidence in making the similarity judgement, and provide written rationale detailing what elements of each photo supported your decision. Your participation in this study will take about 8 – 12 minutes. We expect that 100 people will take part in this research study. You can choose not to answer any question you do not wish to answer. You can also choose to stop taking the survey at any time. You must be at least 18 years old to participate. If you are younger than 18 years old, please stop now. The possible risks to you in taking part in this research are:§ You will be asked to view historical and modern photos of buildings in Durham, NC. If viewing these materials is too uncomfortable, you may exit the survey at any time.§ Potential loss of confidentiality of data. To protect your identity as a research subject, no identifiable information will be collected. If you have any questions about this research, please contact the Investigator named at the top of this form by emailing jeffrey.robbins@unc.edu. If you have questions or concerns about your rights as a research subject, you may contact the UNC Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

End of Block: Welcome and Informed Consent

Start of Block: Same Baseline

Q2 Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Q3

Q4 Is this the same place?

- Yes (1)
- No (2)

Q5 How do you feel about your assessment?

	Unsure	Confident
1 ()		

Q6 How many places do you see?

Enter a value between 0 - 10 in whole numbers.

_____

End of Block: Same Baseline

Start of Block: Different Baseline

Q7 Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Q8

Q9 Is this the same place?

- Yes (1)
- No (2)

Q10 How do you feel about your assessment?

	Unsure	Confident
1 ()		

Q11 How many places do you see?

Enter a value between 0 - 10 in whole numbers.

_____

End of Block: Different Baseline

Start of Block: Moto

Q12 Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Q13

Q14 Is this the same place?

- Yes (1)
- No (2)

Q15 How do you feel about your assessment?

	Unsure	Confident
1 ()		

Q16 How many places do you see?

Enter a value between 0 - 10 in whole numbers.

_____

End of Block: Moto

Start of Block: Liberty

Q17 Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Q18

Q19 Is this the same place?

- Yes (1)
- No (2)

Q20 How do you feel about your assessment?

	Unsure	Confident
1 ()		

Q21 How many places do you see?

Enter a value between 0 - 10 in whole numbers.

_____

End of Block: Liberty

Start of Block: Rail

Q22 Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Q23

Q24 Is this the same place?

- Yes (1)
- No (2)

Q25 How do you feel about your assessment?

	Unsure	Confident
1 ()		

Q26 How many places do you see?

Enter a value between 0 - 10 in whole numbers.

_____

End of Block: Rail

Start of Block: Gray

Q27 Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Q28

Q29 Is this the same place?

- Yes (1)
- No (2)

Q30 How do you feel about your assessment?

	Unsure	Confident
1 ()		

Q31 How many places do you see?

Enter a value between 0 - 10 in whole numbers.

_____

End of Block: Gray

Start of Block: HouseReloc

Q32 Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Q33

Q34 Is this the same place?

- Yes (1)
- No (2)

Q35 How do you feel about your assessment?

	Unsure	Confident
1 ()		

Q36 How many places do you see?

Enter a value between 0 - 10 in whole numbers.

_____

End of Block: HouseReloc

Start of Block: Layered

Q37 Timing
First Click (1)
Last Click (2)
Page Submit (3)
Click Count (4)

Q38

Q39 Is this the same place?

- Yes (1)
- No (2)

Q40 How do you feel about your assessment?

	Unsure	Confident
1 ()		

Q41 How many places do you see?

Enter a value between 0 - 10 in whole numbers.

_____

End of Block: Layered

Start of Block: Moto - qual

Q42

Display This Question:

If Q14 = Yes

Q43 You previously stated that these photos were the same place.

Display This Question:

If Q14 = No

Q44 You previously stated that these photos were not the same place.

Q45 Please provide 1 - 5 sentences for what led you to this determination.

_____

_____

_____

_____

_____

End of Block: Moto- qual

Start of Block: Liberty - qual

Q63

Display This Question:

If Q19 = Yes

Q64 You previously stated that these photos were the same place.

Display This Question:

If Q19 = No

Q65 You previously stated that these photos were not the same place.

Q66 Please provide 1 - 5 sentences for what led you to this determination.

_____

_____

_____

_____

_____

End of Block: Liberty - qual

Start of Block: Rail - qual

Q67

Display This Question:

If Q24 = Yes

Q68 You previously stated that these photos were the same place.

Display This Question:

If Q24 = No

Q69 You previously stated that these photos were not the same place.

Q70 Please provide 1 - 5 sentences for what led you to this determination.

_____

_____

_____

_____

_____

End of Block: Rail - qual

Start of Block: Gray - qual

Q71

Display This Question:

If Q29 = Yes

Q72 You previously stated that these photos were the same place.

Display This Question:

If Q29 = No

Q73 You previously stated that these photos were not the same place.

Q74 Please provide 1 - 5 sentences for what led you to this determination.

_____

_____

_____

_____

_____

End of Block: Gray - qual

Start of Block: HouseReloc - qual

Q75

Display This Question:

If Q34 = Yes

Q76 You previously stated that these photos were the same place.

Display This Question:

If Q34 = No

Q77 You previously stated that these photos were not the same place.

Q78 Please provide 1 - 5 sentences for what led you to this determination.

_____

_____

_____

_____

_____

End of Block: HouseReloc - qual

Start of Block: Final Questions

Q46 How do you define "place" using the below statements?

Move the slider to reflect your personal definition.

	Place is made up of the buildings and objects that I see.	Place is made up of the individuals and ideas that meet in a physical space.
1 ()		

Q53 Please select all that apply.

	Have you visually seen this physical site? (1)	Do you know the history of this physical site? (2)
Image:Oldbrick1s (1)	☐	☐
Image:Newgray (2)	☐	☐
Image:Oldmoto (3)	☐	☐
Image:Modern moto (4)	☐	☐
Image:Oldrail (5)	☐	☐
Image:Churchstgarage (6)	☐	☐
Image:Old liberty (7)	☐	☐
Image:Newliberty (8)	☐	☐
Image:Yellow house (9)	☐	☐
Image:Redhouse (10)	☐	☐

Q47
You are viewing new information about your current location's history on your mobile device.

How do you approach that new information?

Move the slider to reflect your personal view.

	Skeptical	Trusting
1 ()		

Q48 What is your age?

- < 18 Years Old (1)
- 18 - 22 Years Old (2)
- 23 - 35 Years Old (3)
- 35 - 50 Years Old (4)
- 50 - 65 Years Old (5)
- > 65 Year Old (6)

Q49 How long have you lived in Durham, NC?

- < 1 Year (1)
- 1-3 Years (2)
- 4 - 10 Years (3)
- > 10 Years (4)
- I do not live in Durham, NC (5)

Q50 What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Transgender (3)
- ○ Prefer not to say (4)

End of Block: Final Questions

Start of Block: Citation and Close

Q54
Please scroll to the bottom of the page and click the next arrow button one final time to submit your responses.

References

Q56

Kueber, G. (2007) No title. [Photograph] Open Durham.
https://www.opendurham.org/buildings/carpenter-motor-co-600-east-main-street

Kueber, G. (2019) No title. [Photograph] Open Durham.
http://www.opendurham.org/buildings/326-w-geer-st

No author. (1974) No title. [Photograph] Open Durham.
https://www.opendurham.org/buildings/first-federal-southbank-building

Pyne, G. (nd) No title. [Photograph] Open Durham.
http://www.opendurham.org/buildings/liberty-warehouse-no-3

No author. (ca 1968) No title. [Photograph] Open Durham.
https://www.opendurham.org/buildings/union-station

No author. (ca 1960) No title. [Photograph] Open Durham.
https://www.opendurham.org/buildings/graybar-electric-303-south-duke-st

No author. (ca 1995) No title. [Photograph] Open Durham.
http://www.opendurham.org/buildings/tate-house-1001-edith-street-former-1704-markham

No author. (nd) No title. [Photograph] Open Durham.
https://www.opendurham.org/buildings/carpenter-motor-co-600-east-main-street

End of Block: Citation and Close

Appendix B: Codebook

Thematic Analysis Code Book and Occurrence Counts

Code	Description	Occurrence Count
Personal Experience	Respondent cited personal knowledge, history, or lived experience as justification for similarity assessment.	24
Constructivist		
Function	Respondent cited a change in a building's intended use as support for place dissimilarity.	7
Social Interaction	Respondent cited a change in a building's social interactions over time as support for place dissimilarity.	3
Digital Medium		
Acknowledged Mediation	Written recognition by the respondent of interaction with a digital place representation. The response included one or more of the following words: picture, pictures, image, images, photo, photos, photograph, or photographs.	51
Media Properties	The response included discussion about photo angle or photographer implied physical positionality.	13
Place defined by aesthetics		

Architectural Features	Respondent identified specific architectural features used in the similarity assessment, including windows, brick, door opening, column posts, or rooflines.	50
Recurring Residential Design	Respondent articulated residential homes as derived from a set of house plans often repeatedly deployed within a community/neighborhood.	13
Structure	Respondent supported similarity assessment based on a determination of built environment visual similarity.	119
Text Features	Respondent identified recurring text to support the similarity assessment.	13
Placed defined by geographic location		
Environmental Anchor	Respondent described finding or looking for similar features in the peripheral environment.	41
Infrastructure	Respondent identified specific infrastructure features used in the similarity assessment, including power lines, fire hydrants, sidewalks, roadways, or railroad tracks.	47
Location	Respondent supported similarity assessment based on a determination of geographical location similarity.	24